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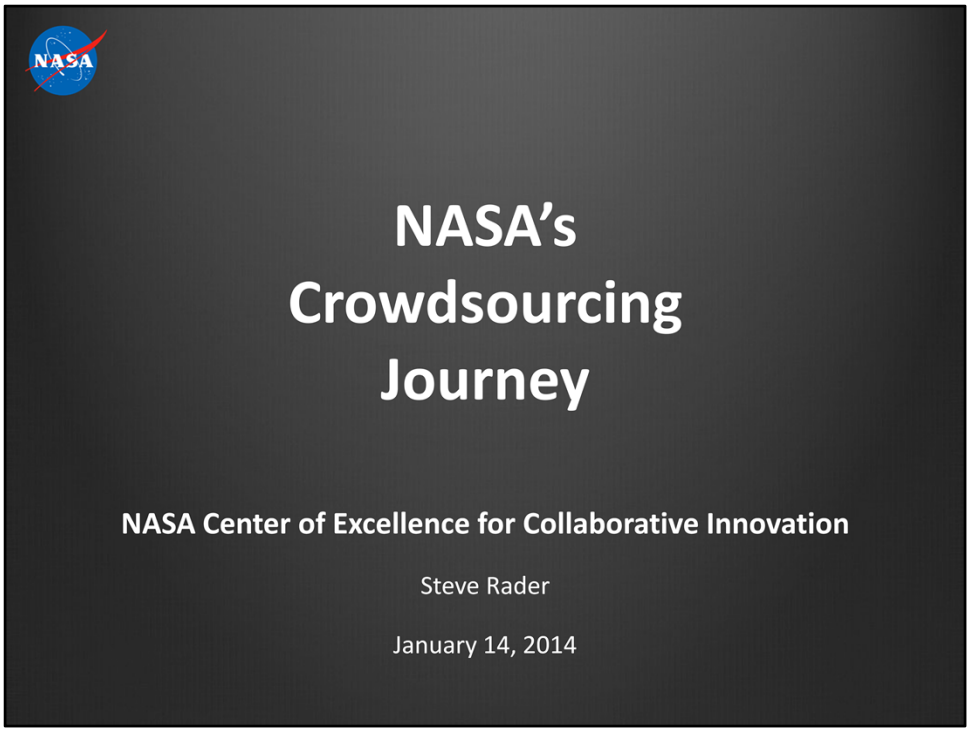

Good morning (or afternoon for some on the east coast). As Norah said, my name is Steve Rader, I'm the deputy manager for NASA's Center of Excellence for Collaborative Innovation (or as we refer to it "CoECI").

Today I'd like to walk you through the story of crowdsourcing at NASA.

A journey I might add, that we are still on.

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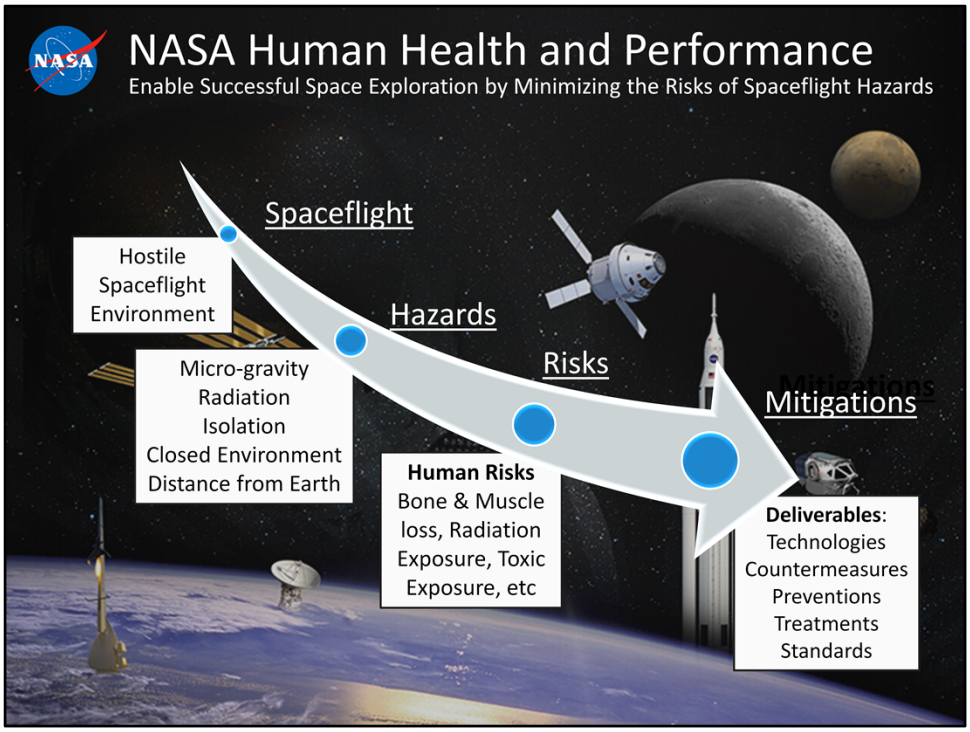

This journey started back around 2005 with Jeff Davis – head of what was then the Space & Life Sciences Directorate at Johnson Space Center.
Now the Human Health and Performance (HH&P) Directorate.

So, generally speaking, this organization focuses on the health and performance of the humans NASA puts in space….. <Explain the chart>.

Hostile Spaceflight **Environment**

Creates **Hazards** (micro-gravity, radiation, isolation, closed environment, distance from Earth)

Which are effectively **risks to Humans** (bone/muscle loss, radiation exposure, toxic exposure, etc)

Risk Mitigation: 42 human system risk identified for mitigation for space flight (medical, environmental, physiological)

And this organization is responsible for **developing systems & techniques** to mitigate these risks (so we can ultimately use humans to explore, live, & work in Space).

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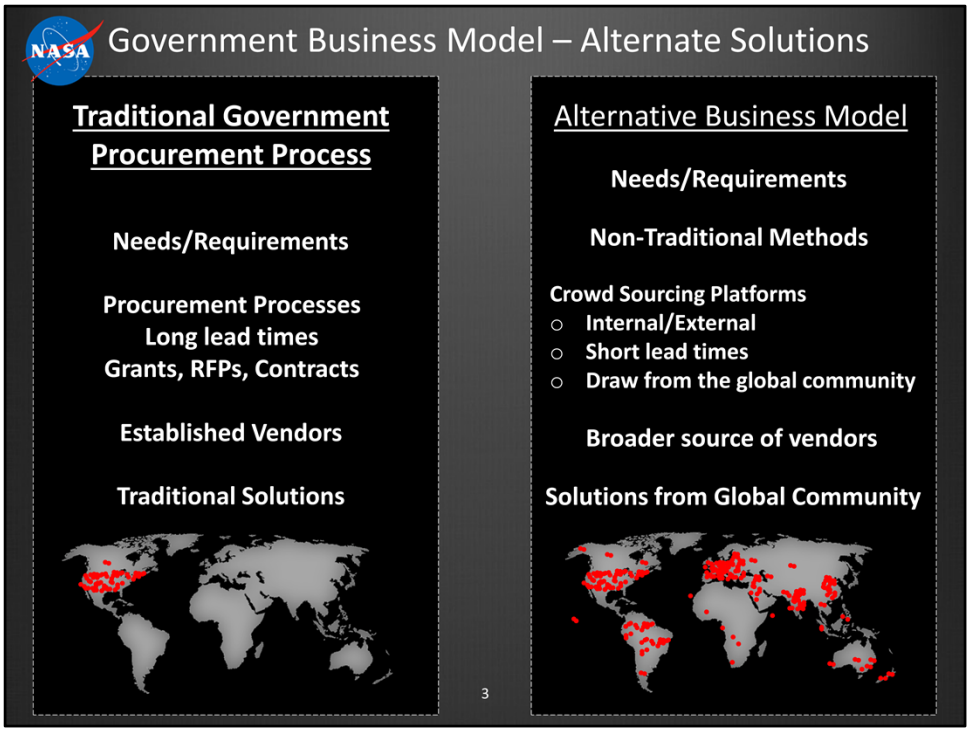
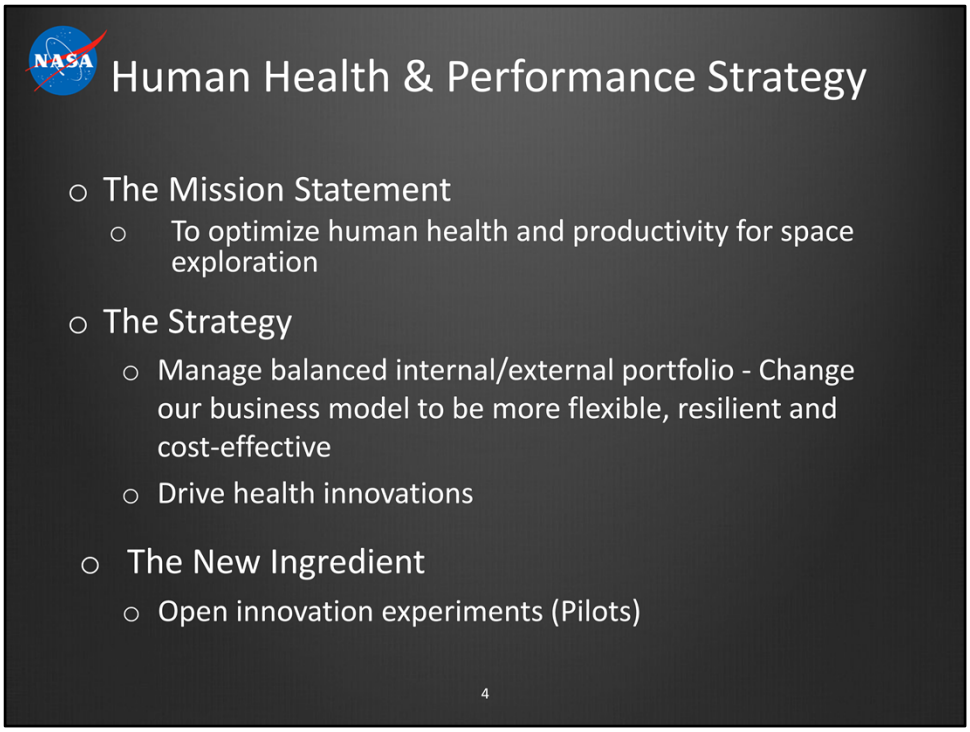


So at the time, NASA was going through a period were
Budgets got severely reduced – 40% reduction for R&D, and our traditional model (refer to chart) was becoming less effective at yielding results.

Jeff took a Harvard Business School class on collaborative innovation models & got to know Karim Lakhani and some of the work he had been doing in this area,
…and started to see and embrace some of the new Alternate Business Models of open innovation and crowdsourcing



So given the directorate's mission statement… To optimize human health and productivity for space exploration

Jeff worked to develop a strategy to try and change the business model to be more flexible, resilient and cost-effective
AND to really intentionally DRIVE health innovations.

Initially, his team started benchmarking with other organizations such as P&G, General Mills, GE etc.
Seeing companies like P&G: Connect & Develop – Extending open innovation
10 to 23 brands (billion $ ones) – without increasing their R&D staffing

So in addition to these benchmarking efforts, Jeff set off on the course of bringing open innovation to his organization. ..

The new Ingredient was the Open Innovation Pilots.
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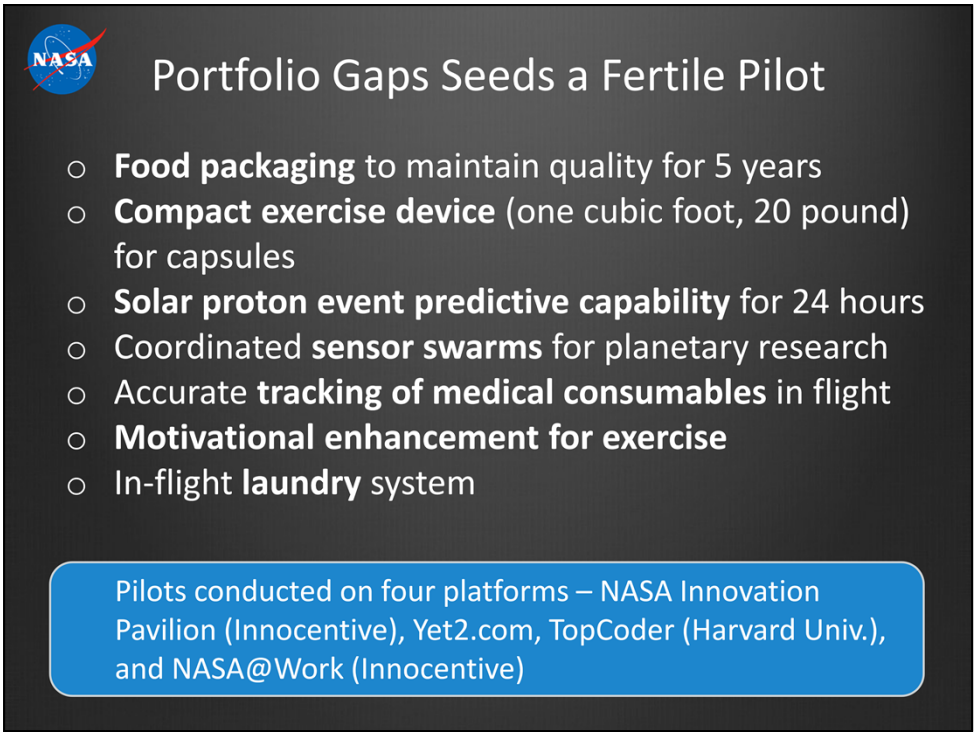


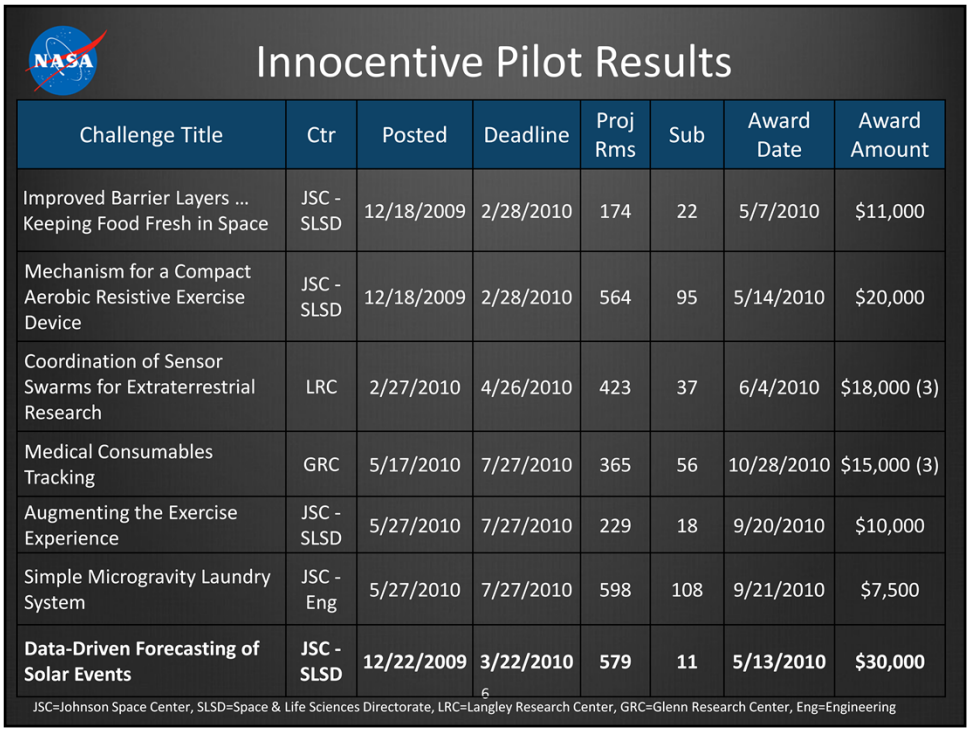
NASA embarked on a series of challenges.

Listed here are the 7 pilot challenges that were launched on Innocentive <highlight chart>

Additionally, NASA ran several pilot challenges on Yet2.com and TopCoder… and began looking at internal platform options like NASA@work.

<NEXT CHART>

REFERENCE IF NEEDED:
JSC's success piloting a TopCoder challenge:
Algorithm challenge: Optimize algorithm that supports medical kit design. The competition lasted 10 days and 2800 solutions were submitted by 480 individuals.
The challenge team actually incorporated results from this competition into the Integrated Medical Model.
The team felt this process was more efficient than strict internal development efforts.



I just wanted to flash up some details on the pilots we ran on the Innocentive platform:

As you can see… broadly,
- we gain experience working with different organizations across NASA…
- Most of our challenges ran for just a couple of months
- We had really great responses with hundreds of project rooms/solvers and lots of submissions.
- You can also see, we got these great results with relatively modest prize amounts ranging from around $7K up to $30k.
- I should note that these durations and costs are only for the challenges and that additional time and resources were used to develop the challenges.

The improved **food packaging** challenge closed with 174 total project rooms representing 33 different countries. A total of sixteen proposals were reviewed and a partial award went to one proposal submitted by a Russian scientist. The solution was utilization of graphite foil as a barrier in food packaging to extend the shelf life of food products. This solution has really advanced NASA's thinking about food packaging materials.

The **compact resistive exercise** challenge closed with 564 project rooms representing 52 countries. A total of 60 individual proposals were received and one proposal from a mechanical engineer in Massachusetts was chosen for full award. The solution was for a compact pneumatic suction exercise device similar to an exercise device that is currently on the International Space Station (ISS), the Advanced Resistive Exercise Device (ARED). However, the proposed device is much more compact, lighter weight, and novel in terms of how the exercise device and its components were packaged.

The **sensor swarming** challenge closed with a total of 423 project rooms representing 49 individual countries. A total of 22 individual proposals were reviewed and three proposals from solvers in Italy (2) and California (1) were awarded partial awards. The solutions were novel ideas for how sensor nodes could make decisions autonomously and without coordination with other swarms. The ideas also helped re-characterize the original problem statement for future research and collaboration efforts.

The **medical consumables tracking** challenge closed with a total 365 project rooms and 36 proposals representing 16 different countries.

The **augmented exercise experience** challenge closed with a total of 229 project rooms and 18 representing nine different countries.

The **simple microgravity laundry system** challenge closed with a total of 598 project rooms and 70 representing 20 different countries. Note that this was one challenge where we did NOT really find a solution, but learned a lot about appropriate scoping of challenges.

The Data Driven Forecasting of Solar Events…
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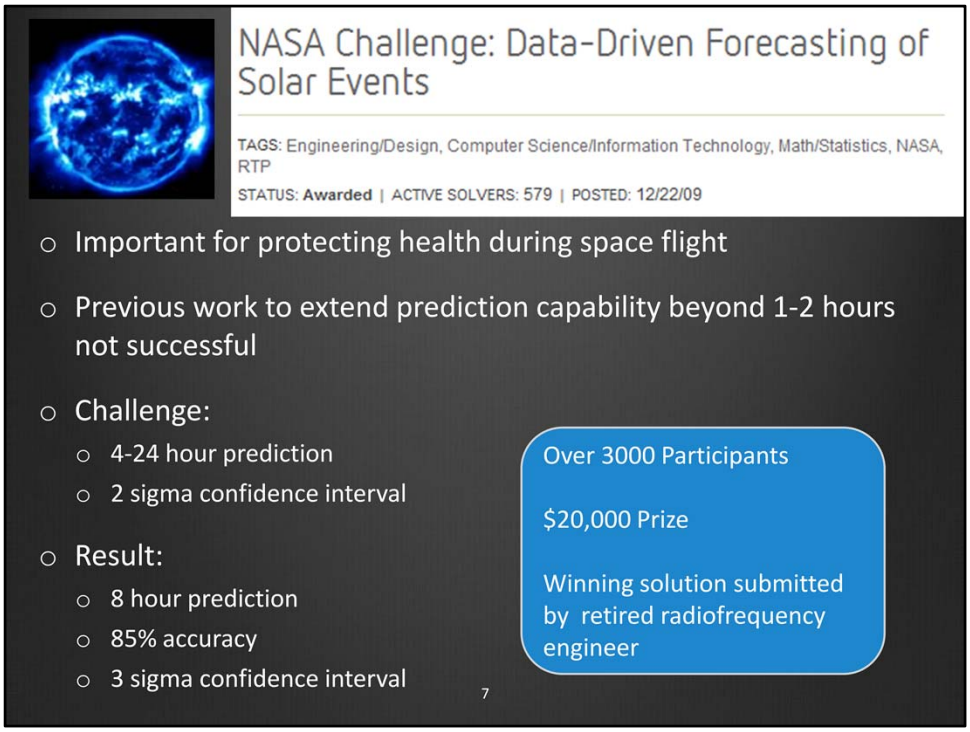


Energetic particles emitted by the sun during Solar Particle Events (SPEs) increase exposure above background levels and could be mission limiting.

No current method to predict SPE…Multiple observational platforms currently exist to monitor solar activity.

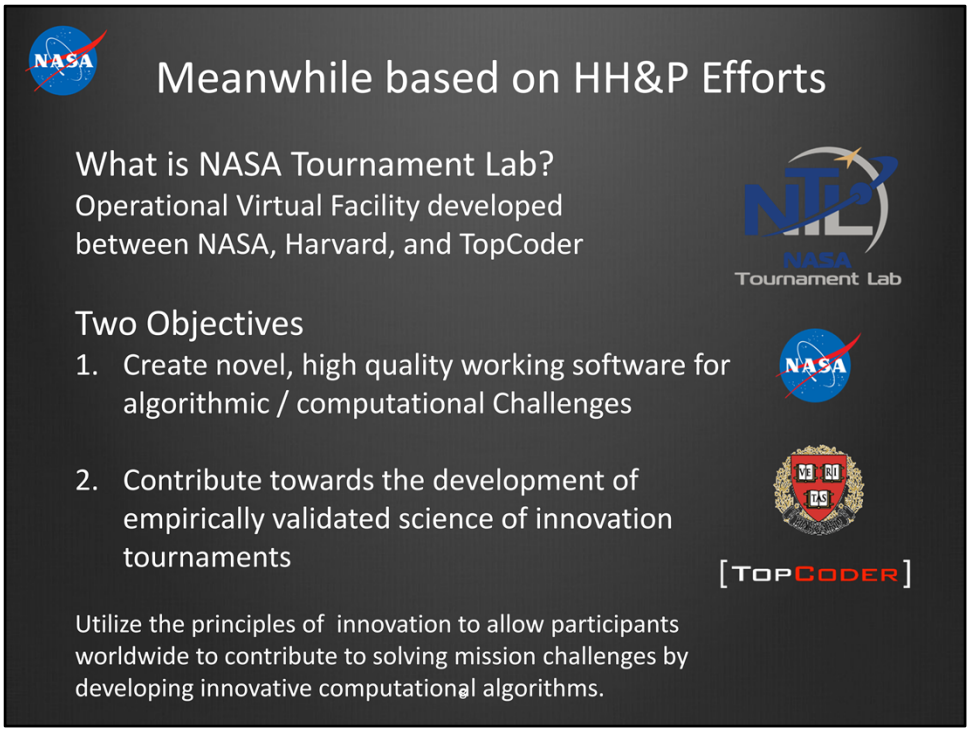
Of particular interest for mission operations is the ability to predict or forecast periods from 4 to 24 hours of low probability of having an SPE, i.e., **an 'All-Clear' forecast**

<Click to ANIMATE>

This challenge had over 3000 participants (the power of NASA brand)
579 total project rooms representing 53 different countries
95% of the solvers had never worked on a NASA project.
$20K prize.

A total of four individual proposals were selected for final review, and one proposal from a retiree in New Hampshire was chosen for a full award.

The solution was a mathematical model that predicted Solar Particle Events (SPE) using ground based data.



Meanwhile, Jason Crusan at NASA HQ had met Jeff and become interested in these methods and began working with TopCoder.

Jason Crusan is currently the Director of NASA's Advanced Exploration Systems.

He formed the NASA Tournament Lab (NTL) by initiating a contract with Harvard who then subcontracted with TopCoder…. To start using and studying these new innovation approaches.

This NTL has been a very good platform for both studying and executing challenges.

NASA Tournament Lab (NTL)

- Engage existing community to solve real-world problems through competition
  - Image, landscape, motion detection
  - Modeling and prediction
  - Cost-path problems (logistics)
  - User interface design
  - System architecture and implementation
- Investigating
  - Competition structure and incentives
  - Problem selection
  - Problem design
  - Solution integration
  - Principal Investigator: Prof. Karim Lakhani, HBS
  - Chief Economist: Prof. Kevin Boudreau, LBS
  - NASA Lead: Jason Crusan

Continuing to Build on Success

- Pilots lead White House Office of Science and Technology Policy (OSTP) Request for NASA to serve as a resource for other Federal Agencies
  - NASA Center of Excellence for Collaborative Innovation established November 2011.

Visit www.nasa.gov/offices/COECI/ for more information

Together, Jeff and Jason began promoting these methods both inside and outside of NASA.
(in fact, one of my first exposures to these groups was at NASA's Program Management Challenge in Feb 2011 where they were showcasing the results of the pilots and bringing in these platform vendors to talk.)

The White House Office of Science and Technology Policy (OSTP - who was also interested in getting some of these new approaches working in the Federal Gov't) requested that NASA establish a Center of Excellence for Collaborative Innovation (COECI) for all U.S. federal agencies to share in best practices and results of challenges and prize competitions conducted across a wide range of disciplines to spur innovation.

And thus NASA stood up the Center of Excellence for Collaborative Innovation in November of 2011 with NASA management approval.
I should note that Jason Crusan and Jeff Davis are the Director and Deputy of CoECI.

So, over the past 2 years, we've been working across NASA and several federal agencies to run help the organizations run challenges and really make these methods part of their "toolbox" for finding innovative solutions.

CoECI (As we call it), currently has several contracted platforms that we use.

NASA@work - Internal INNOCENTIVE
NASA PAVILION on INNOCENTIVE – open innovation
NASA TOURNAMENT LAB (NTL) NASA/Harvard/TopCoder
YET2.COM (technology portfolio matching)

We are currently working on follow-on contract mechanisms that will allow us to expand the number and type of open innovation platforms available.

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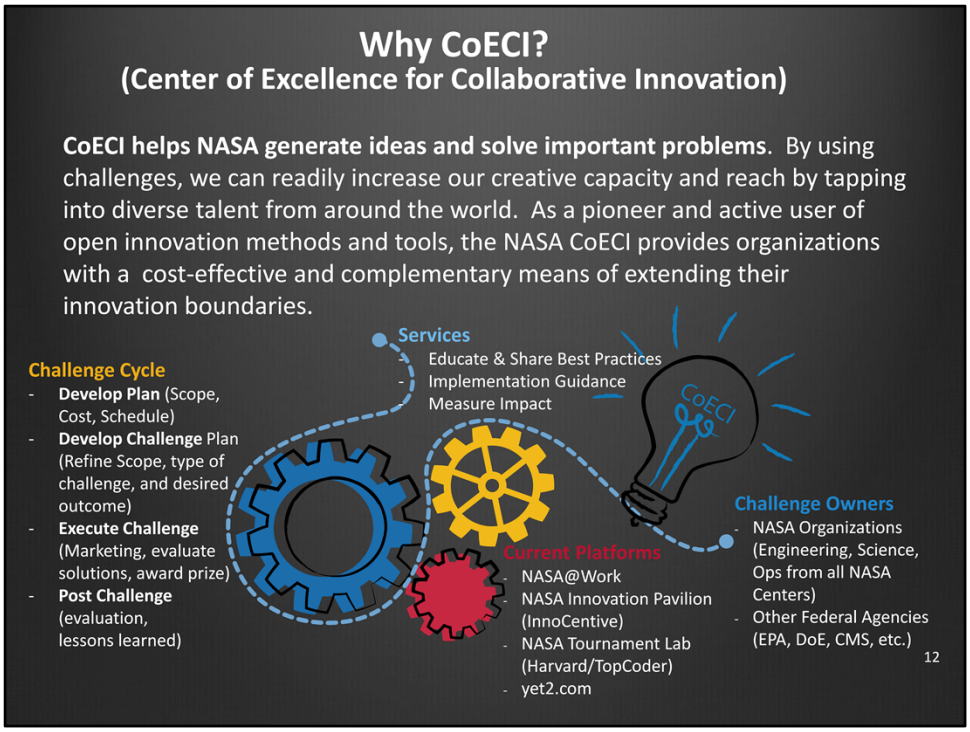

This is our official “About page” for CoECI… but we mainly facilitate the planning and execution of challenges at NASA and across the federal government.

This includes some education and outreach… some contract management, and a lot of working with individual and organizations to help them successfully leverage these new approaches.

Here is our org… and you'll notice that our director and deputy are in fact the original advocates of open innovation.

So, let me shift gears now and walk you through each of the platforms we use and a few of the challenges that we've run on each.

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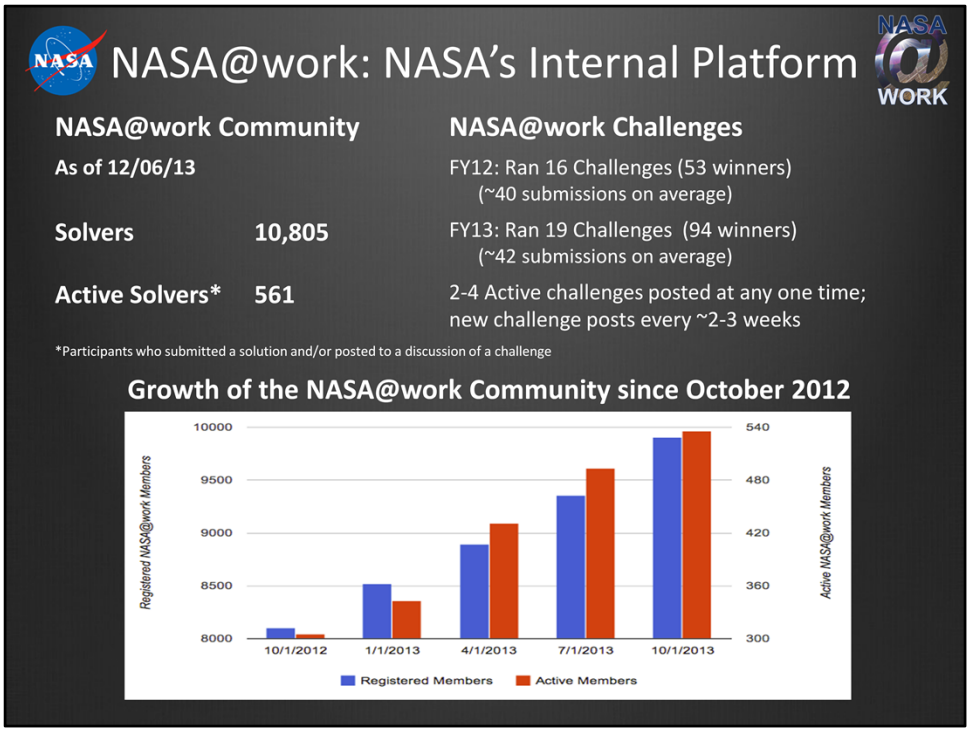

<Run through the basic chart elements>

From Oct 12 to Oct 13, our registered users have gone from 8100 to 9906 (22% growth)
But we are really excited that in that same time, our active users have gone from 305 to 536 (76% growth)

Note that active just means they log on the site…. They all get emails describing the latest challenge… so we assume that it is mainly those that have some interest (skill) in the challenge click on through to the site.

One of the things we've learned with crowds is that you don't necessarily want lots of responses (typically means you have the statement too broad)… but rather a few solutions from people that really have good stuff. Some of our challenges have just 2-3 submitted solutions (but almost all of them are valuable).

Here are just some of the challenges that we've run on our NASA@work platform over the last year (and a couple are still running).

NASA@work: Highlights

Type: Solution Seeking

Problem: Need an easier and more accurate way to collect dietary data from astronauts inflight

Posts: 100
Unique Solvers: 70
Winners: 1

Solution: Idea for an iPad app. Resulted in ISS Food Intake Tracker (FIT) app developed via a NASA Tournament Lab (NTL) Challenge

Seeking Efficient Method to Collect Dietary Data in Space

Type: Knowledge Seeking

Problem: Seeking internal proposals for the next Centennial Challenge. Winners eligible for funding of an engineer for six months.

Submissions: 29
Unique Solvers: 21

Solution: Challenge currently "Under Evaluation;" largest number of new active participants to date

Seeking Ideas for New Technology Demonstration Prize Competitions

Type: Expertise Seeking

Synopsis: Need to identify expertise and tutorial tools to understand a specific encoding method

Posts: 18
Unique Solvers: 9
Winners: 4

Solution(s): Identified viable tools and experts at two different centers (outside his own center)

Seeking Hands-On Tutorial: Reed Solomon Encoding Method

In addition to all of the great results that we got out of the innocentive Pilots I shoed earlier, we have also continued to get great results from our Innocentive Challenges:

Two key NASA challenges on Innocentive that I want to highlight were

Non-Invasive Measurement of Intra-Cranial Pressure –
This is important for us in spaceflight due to the changes in the way body fluids work in Zero-G (ref…bloated faces). Eyesight
We are still understanding the affects of this and have needed a way to measure the intra-cranial pressure.
There is no validated tool to quantify intracranial pressure *non-invasively*.

- Clinical Gold Standard methods are invasive
  1. Lumbar puncture
  2. Cranial implant
- Accurate pre-, in-, and postflight ICP measurements are required to prove or disprove the intracranial pressure hypothesis and quantify the extent and time course of ICP changes.

- Techwatch and market surveys indicated that the current state of technology was insufficient to meet NASA's research needs.

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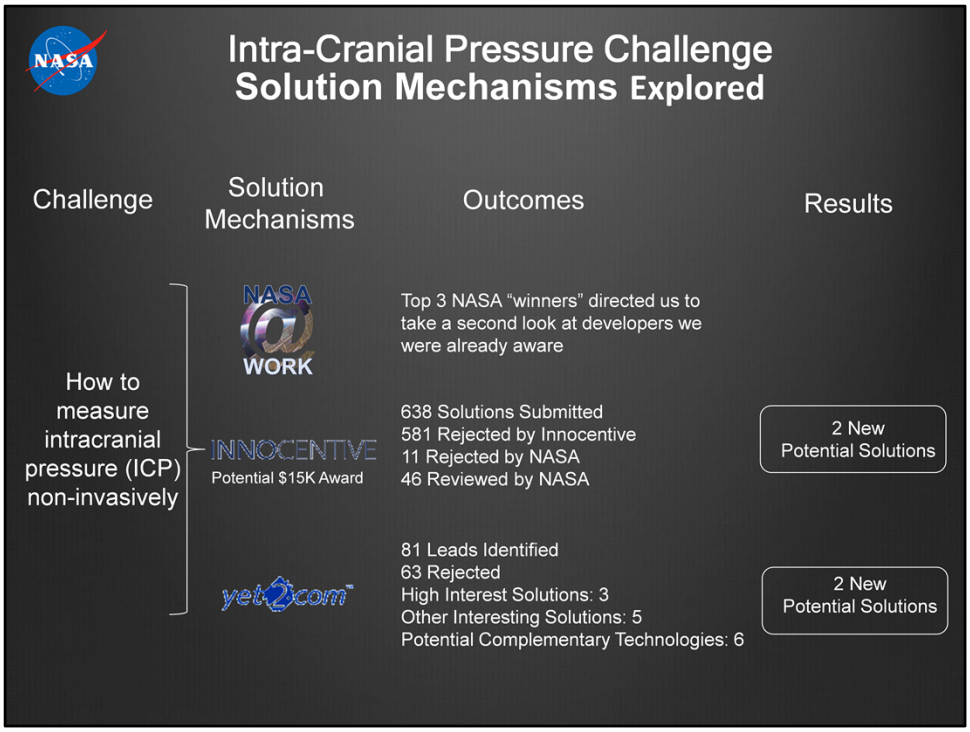
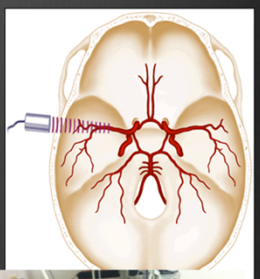

Intra-Cranial Pressure Challenge
Solution Mechanisms Explored
Challenge
Solution Mechanisms
Outcomes
Results
How to measure intracranial pressure (ICP) non-invasively
NASA @ WORK
Top 3 NASA "winners" directed us to take a second look at developers we were already aware
INNOCENTIVE
Potential $15K Award
638 Solutions Submitted
581 Rejected by Innocentive
11 Rejected by NASA
46 Reviewed by NASA
2 New Potential Solutions
yet2com
81 Leads Identified
63 Rejected
High Interest Solutions: 3
Other Interesting Solutions: 5
Potential Complementary Technologies: 6
2 New Potential Solutions

Intra-Cranial Pressure Challenge
Innocentive Results

UCLA's Non-invasive Intracranial Pressure Calibration Framework (NICF)

- Algorithm developed from a database of cerebro-vascular parameters, non-invasive and invasive ICP measurements. Developed under NIH grant.
- UCLA is populating a database of individual input/output models between invasive ICP and nICP signals from non-astronaut population.
- Cerebral blood flow velocity signal measured at the middle cerebral artery using conventional Transcranial Doppler (TCD() ultrasound and arterial blood pressure signals
- We can get TCD with existing Ultrasound on the International Space Station (ISS).



Intra-Cranial Pressure Challenge
Innocentive Results

Thinker: An Intelligent Intracranial Pressure Monitor

- Miniature physiological data acquisition system.
- Algorithm that predicts ICP from digitized pressure waves, i.e. plethysmography.
- Commercial digital technology with innovative sensor architecture, electronics and software/firmware techniques. Bluetooth, RF
- Utilizes MIMIC II database with ICU patient data.
- Algorithm needs work.

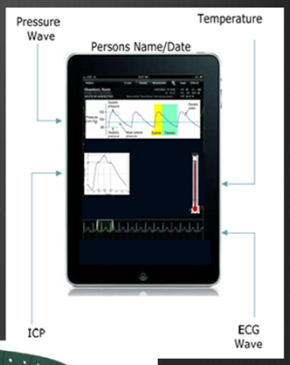


Figure 10 Thinker's Photoplethysmography Mechanical Housing

Kevlar Strain Measurement out of Langley: 3 winners ($10K, $5K, $5K) where they were really happy with their results and it is helping them to solve a key problem that we've had with testing inflatable modules that use this Kevlar webbing.

Overall, we ended up with a preferred solution that the challenge owners described as "So simple, so elegant how could we NOT have thought of this ourselves."

Note that we also ran a challenge for USAID on Innocentive dealing with preventing genocide.

One thing to note about Innocentive is what a great platform for really getting "innovation" via a diverse community.
As most of you probably know, there are some great studies that have been done on this platform that show that most of the really innovative ideas, come from outside the technical domain of the problem (solution seeker).

On our NTL platform, we have mainly been software & algorithm challenges that benefit from a more specialized platform community (since TopCoder is mainly made up of software and algorithm developers).

- Longeron – solar array power optimization
- ISS-FIT – Food Intake Tracker – iPad App for the crew (astronaut Don Pettit shown here)
- Robonaut 2 – machine vision algorithms.

- Note that additionally, we leverage the **Harvard component** of the NTL to better understand the mechanisms and incentive models that work best in this new area.

Challenge Highlights

- **Collective Minds & Machines Exploration**
  - Machine learning algorithms based on crowd tagged imagery.
- **Asteroid Image ID**
  - Machine learning algorithms based on crowd tagged imagery.
- **Lunar Mapping and Monitoring Project (LMMP)**
- **Ka-Band Objects Observation & Monitoring (KaBOOM)**
  - Optimized algorithm for tracking multiple asteroids with an array of antennas.
- **Disruption/Delay Tolerant Network (DTN)**
  - Attempting to solve a problem with distributing security keys in a disrupted/delayed network.
- **QuakeFinder**
  - Algorithm for validating the use of magnetometers for detecting earthquakes.
- **HEC Climate Model Virtual Hosting**
  - Working to improve climate modeling with diverse data sets.
- **Planetary Data System (PDS) 3**
  - Providing improved API access to planetary data

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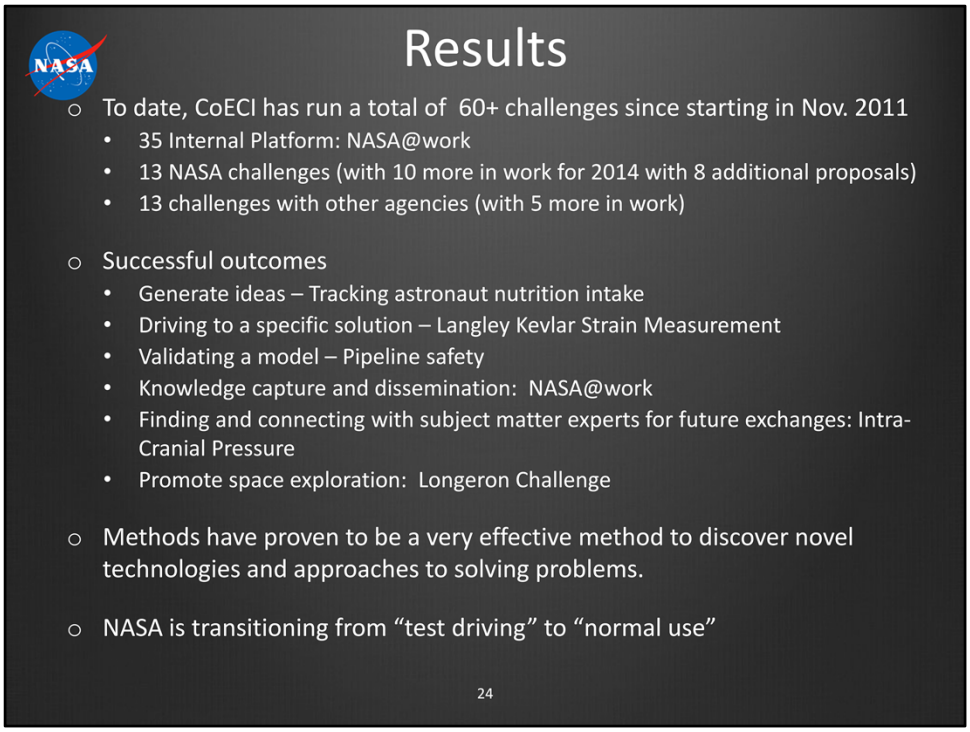
<Go through the list>

Additionally in other agencies:
EPA – Mobile app for Cyanobacteria, Toxcast
DOE – Wave Energy
CMS – A number of apps
OPM – Payment app
DoD – Possible Exoskeleton
DOJ – Possible crime pattern algorithm

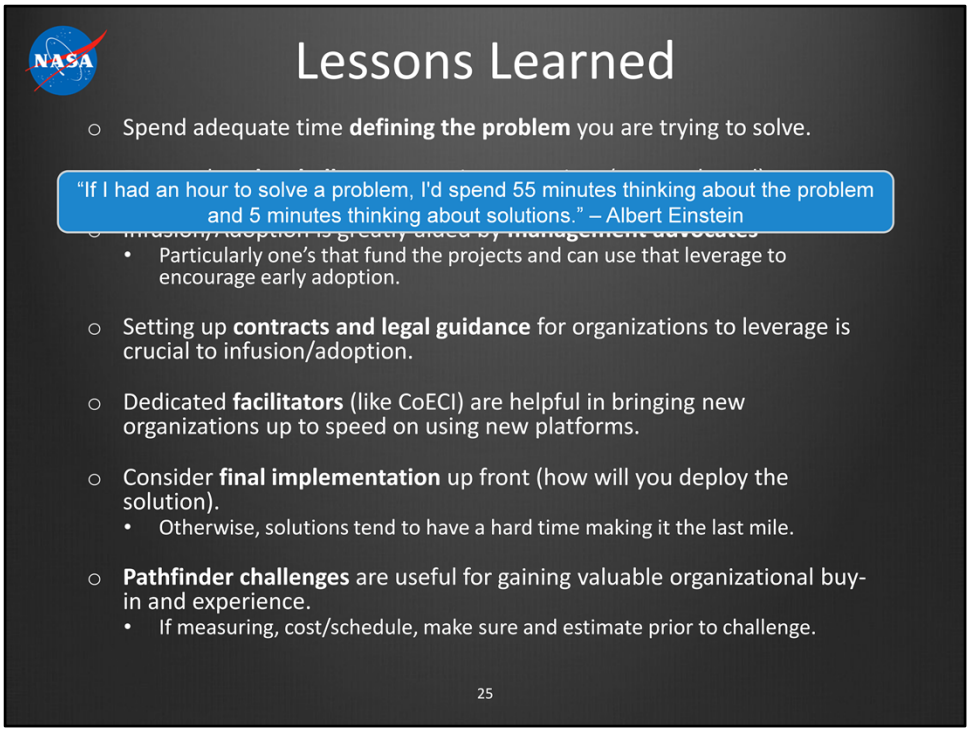


13 pilots = 6 Yet2.com + 7 Innocentive (topcoder??)
35 NASA@work (per status chart w/ summaries for 12 and 13)
NASA
1. Detecting Impact Craters
2. Big Data Challenge
3. PDS
4. HEC-1
5. Kevlar
6. ICP
7. Robonaut
8. Longeron
9. ISS FIT
10. DTN-DTPC
11. DTN-LTP
12. DTN-SK
13. Collective Minds & Machines
14. USAID – Atrocity Prev
15. USAID – Secure Comm
16. USAID – Identifying Indicators of Vulnerability (MODEL)
17. USAID - Atrocity Prev Model
18. OPM – SCRD
19. CMS – Medicate provider enrollement screening
20. CMS – Fraud Prevention
21. CMS – Open Payments
22. USTPO – Patent Algorithm
23. USTPO – Patent Labeling 2 Algorithm
24. EPA – Cyano Bacteria App
25. EPA – Toxcast
26. DOE – WARP

27. KaBOOM
28. SMG
29. Asteroid
30. LMMP
31. Earth Science API
32. CFS Code Review
33. PDS Cassini
34. Robonaut 2 – TBD
35. HEC 2
36. Mars Ballast (Innocentive)
37. DTN – Exchange
38. DTN – Killer App
39. DTN – BP Interop
40. DTN – Configuration
41. DTN – Multi-Domain Routing
42. DTN – Firewall
43. DTN – Penetration Testing
44. CFS - DTN

Other Agency Possible:
DoD – Talon/Exoskeleton
DOJ - ??
Intel?
DoE – Sunshot Initiative

Pilots or others??
Laundry system
Augmenting the Exercise Experience
Medical Consumables Tracking
Zero Robotics (Spheres)
Zero Robotics STEM Video Challenge



<Animation…. Click each point>

Center of Excellence Best Practices

- Serve in a facilitator & integrator role.
  - Bring customer organization together with platform vendor with challenge experience.
- Work out procurement and legal strategies.
- Provide opportunities for education and sharing between practitioners.
- Track and share results (including costs, lessons learned, etc.).

- Ensure challenge owners do not underestimate the investment required (make the up front investment).
- Execute a clear communications strategy.

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Facilitation
<click>
Procurement & Legal
<click>
Education & Sharing
<click>
Tracking Results
<click>
Don’t underestimate the investment required…
<click>
Clear Communications Strategy – web/social media…etc. (really focus on both communicating with challenge owners… but also outreach to our solver community.

Conclusion

- NASA's crowdsourcing journey has been very successful in driving open innovation.
- CoECI is working to infuse open innovation methods and tools across NASA and the Federal Government.
- As we continue into the future, we are hoping to make these methods and platforms part of the normal research and development toolbox.

1. Regarding your NASA@Work program, what support do you offer internal project managers?
2. What are some near and short term adjustments the CoECI team is doing in 2014?
3. You originally engaged in Open Innovation due to budget pressures, what are the reasons you continue with it?